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REPORT ON POLLUTION OF LAKE ERIE AND ITS TRIBUTARIES

PART I. LAKE ERIE

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Report on Pollution of Lake Erie and Its Tributaries

Part I

LAKE ERIE

July, 1965

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See also Part 2, PB-260 274 and report dated Aug 65, PB-229 712.

16. Abstracts

Two years of studies are summarized in this report on pollution of Lake Erie and its tributaries. Quality characteristics of the waters as they currently exist are considered. Effects of waste discharges on water uses are evaluated and principal problems and needed corrections are summarized. Part 1 of the report concerns the main body of Lake Erie.

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TABLE OF CONTENTS

		Page
PART 1	LAKE ERIE	
I	Summary of Conclusions and Recommendations	1
II	Introduction	5
III	Description of Area	5
IV	Degradation of Lake Erie	17
V	Waste Inputs to Lake Erie	24
VI	Federal Installations	30
PART 2	TRIBUTARIES IN OHIO, INDIANA, AND MICHIGAN	
I	Introduction	51
II	Maumee River Basin	52
III	Western Ohio	71
IV	Rocky River Basin	76
V	Cuyahoga River Basin and Cleveland Lakefront	80
VI	Eastern Ohio	89
VII	Detroit River and Michigan Tributaries	97
PART 3	TRIBUTARIES IN PENNSYLVANIA AND NEW YORK	
I	Introduction	103
II	Pennsylvania	104
III	Western New York	110
IV	Erie-Niagara	115

LIST OF FIGURES

Figure	Title	Page
Part 1		
III-1	Lake Erie Locality Map	7
III-2	Lake Erie Bottom Deposits and Topography	8
III-3	Lake Erie Currents Generalized Surface Flow	11
III-4	Lake Erie Currents, Summer 1964	12
IV-1	Dissolved Oxygen, Bottom Waters, August 14-31, 1964	22
Part 2		
II-1	Maumee River Basin	53
III-1	Western Ohio Basin	72
IV-1	Rocky River Basin	77
V-1	Cuyahoga River Basin	81
VI-1	Eastern Ohio Basin	90
VII-1	Michigan Basin	98
Part 3		
II-1	Pennsylvania Basin	105
III-1	Western New York Basin	111
IV-1	Erie-Niagara Basin	116

LIST OF TABLES

Table	Title	Page
V-1	Lake Erie Municipal Waste Treatment Facilities	35
V-2	Industries in Lake Erie Basin Discharging Directly to Public Waters	40
V-3	Industrial Wastes Discharged Directly to Lake-Affected Portions of Rivers	43
V-4	Chloride Inputs to Lake Erie	47
V-5	Omitted	
V-6	Suspended Solids Inputs to Lake Erie	48
V-7	Total Nitrogen Inputs to Lake Eire	49
V-8	Soluble Phosphate Inputs to Lake Erie	50

I - SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Lake Erie and its tributaries are polluted. The main body of the Lake has deteriorated in quality at a rate many times greater than its normal aging processes, due to inputs of pollution resulting from the activities of man.

Identified pollutants contributing to damages to water uses in Lake Erie are sewage and industrial wastes, oils, silts, sediment, floating solids and nutrients (phosphates and nitrates). Enrichment of Lake Erie, caused by man-made contributions of nutrient materials, is proceeding at an alarming rate. Pollution in Lake Erie and its tributaries causes significant damage to recreation, commercial fishing, sport fishing, navigation, water supply, and esthetic values.

Eutrophication or over-fertilization of Lake Erie and the Maumee River is of major concern. Problems are occuring along the lake shoreline and at some water intakes from algal growths stimulated by nutrients. Algal growths can be controlled, and eutrophication of Lake Erie can be retarded and perhaps even reversed by reducing one or more nutrients below the level required for extensive growth.

Soluble phosphate is the one nutrient most amenable to reduction or exclusion from Lake Erie and its tributaries. Present technology is capable of removing a high percentage of soluble phosphates from sewage at a reasonable cost.

More than three-fourths of the soluble phosphates reaching Lake Erie are from municipal waste discharges; this includes some industrial wastes routed through municipal facilities. Proper design and operation of secondary sewage treatment plants will result in significantly greater removal of phosphorus compounds than that produced by primary treatment alone. This will result in substantial reduction of aquatic growths and will be reflected chiefly in a better fishery, a better water supply and better water for recreational uses.

Discharges of municipal and industrial wastes originating in Michigan, Indiana, Ohio, Pennsylvania, and New York are endangering the health or welfare of persons in States other than those in which such discharges originate. This pollution is subject to abatement under the Federal Water Pollution Control Act.

Pollution of the Detroit River and Michigan waters of Lake Erie has been the subject of a previous enforcement conference. Specific recommendations were developed by the Detroit River-Lake Erie Project for all known sources of municipal and industrial wastes in the conference area. At the conference session held June 15-18, 1965,

the Michigan Water Resources Commission agreed to implement the recommendations of the U. S. Department of Health, Education, and Welfare as contained in the "Report on Pollution of the Detroit River, Michigan Waters of Lake Erie, and their Tributaries."

The Maumee, Sandusky, Black, Rocky, and Cuyahoga Rivers and their tributaries, all of which are tributary to Lake Erie in Ohio, are grossly polluted. This pollution is caused by refuse, sewage, and sludge resulting in low dissolved oxygen, algal growths, bacterial contamination, and odors associated with polluted waters. This pollution interferes with water uses for municipal and industrial supply, recreation, fishing, and esthetic enjoyment. Specifically, phenols and nitrogenous compounds cause taste and odor problems in municipal water supplies. Other pollutants found in significant areas of these tributary rivers are oil, silt, and sediment.

Lake Erie and its tributary streams in the Pennsylvania basin are polluted by discharges of municipal and industrial wastes, combined sewer overflows, accidental spills from vessels and industries and wastes from Lake vessels, and land drainage. This pollution has caused taste and odor problems in domestic water supplies, bacterial contamination of bathing beaches, fish kills and algal growths. In addition, wastes which cause the receiving waters to foam, turn blackish-brown, and have a foul odor have interfered with recreation and esthetic enjoyment.

Lake Erie and its tributary streams in the western New York basin and the Erie-Niagara basin in New York are polluted by municipal and industrial wastes. Discharges of these wastes cause interferences with municipal and industrial supplies, recreation, fish and aquatic life. In addition, these wastes cause discoloration of the receiving waters, foul odors and algal growths.

Recommendations

Lake Erie is more than a valuable water resource; it is a priceless natural heritage. The present generation has an obligation to use it wisely and to preserve it for posterity. Each city and town, each industrial firm - each and every citizen of the basin - must bear a share of that responsibility.

Recommendations for abating water pollution interfering with water uses in Lake Erie and its tributaries will be made in two groups: general recommendations, covering the broad objectives of pollution abatement in the conference area, followed by specific recommendations in Parts 2 and 3 of this report, for the solution of particular problems. The specific recommendations are offered in addition to, and not in place of, the general recommendations.

The recommendations which limit the effluent concentration of a particular waste constituent are made with the purpose of reduction of waste loadings from a facility. If changes in concentration are

brought about by increased dilution, combination of outfalls, or other methods without reducing waste loading, a corresponding decrease in recommended waste concentrations will be required.

Municipal Wastes

It is recommended that:

1. Municipal wastes be given secondary biological treatment; such treatment to produce an effluent not exceeding the following concentrations:

   a. Suspended solids - 35 mg/l

   b. Settleable solids - 5 mg/l

   c. Ammonia - 2 mg/l

   d. Phenol - 20 micrograms per liter

   e. Oil - 15 mg/l

   f. 5-day BOD - 20 mg/l

2. Secondary treatment plants be so designed and operated as to maximize the removal of phosphates.

3. Disinfection of municipal waste effluents be practiced in a manner that will maintain coliform concentrations not to exceed 5,000 organisms per 100 ml, and not to exceed 1,000 organisms per 100 ml where the receiving waters in proximity to the discharge point are used for recreational purposes involving bodily contact.

4. All new sewerage facilities be designed to prevent the necessity of bypassing untreated waters.

5. Combined storm and sanitary sewers be prohibited in all newly-developed urban areas, and eliminated in existing areas wherever opportunity is afforded by redevelopment. Existing combined sewer systems be continuously patrolled and flow-regulating structures adjusted to convey the maximum practicable amount of combined flows to and through treatment plants.

6. A program be developed to prevent accidental spills of waste materials to Lake Erie and its tributaries. In-plant surveys with the purpose of preventing accidents are recommended.

7. Unusual increases in waste output and accidental spills to be reported immediately to the appropriate State agency.

8. Disposal of garbage, trash, and other deleterious refuse in Lake Erie or its tributaries be prohibited and existing dumps along river banks and shores of the Lake are to be removed.

Industrial Wastes

It is recommended that:

1. Industrial plants improve practices for the segregation and treatment of waste to effect the maximum reductions of the following:

a. Acids and alkalies

b. Oil and tarry substances

c. Phenolic compounds and organic chemicals that contribute to taste and odor problems

d. Ammonia and other nitrogenous compounds

e. Phosphorus compounds

f. Suspended material

g. Toxic and highly-colored wastes

h. Oxygen-demanding substances

i. Excessive heat

j. Foam-producing discharges

k. Other wastes which detract from recreational uses, esthetic enjoyment, or other beneficial uses of the waters

2. The Michigan Water Resources Commission, the Indiana Stream Pollution Control Board, the Ohio Water Pollution Control Board, the Pennsylvania Sanitary Water Board, and the New York State Department of Health are to undertake action to insure that industrial plants discharging wastes into waters of Lake Erie and its tributaries within their respective jurisdictions institute programs of sampling their effluents to provide necessary information about waste outputs. Such sampling shall be conducted at such locations and with such frequency as to yield statistically reliable values of all waste outputs and to show their variations. Analyses to be so reported are to include: pH, oil, tarry residues, phenolics, ammonia, total nitrogen, cyanide, toxic materials, total biochemical oxygen demand, and all other wastes listed in recommendation #1, under Industrial Wastes.

Waste results to be reported in terms of both concentrations and load rates. Such information will be maintained in open files by the State agencies for all those having a legitimate interest in the information.

Surveillance

The Department of Health, Education, and Welfare will establish water pollution surveillance stations at appropriate locations on Lake Erie and its tributaries. The Department will welcome the participation and assistance of the appropriate State agencies.

II - INTRODUCTION

On the basis of a written request from Governor James A. Rhodes of Ohio, dated June 11, 1965, and on the basis of recent reports, surveys, or studies, and in accordance with section 8 of the Federal Water Pollution Act (33 U.S.C. 466 et seq.), the Secretary of the Department of Health, Education, and Welfare called a conference in the matter of pollution of the interstate and Ohio intrastate waters of Lake Erie and its tributaries (Indiana-Michigan-New York-Ohio-Pennsylvania). The conference is to convene first at Cleveland, Ohio, on August 3, 1965, and to reconvene at Buffalo, New York, on August 10, 1965.

This technical report is based on studies made over the past two years under the supervision of the Department of Health, Education, and Welfare. Data obtained from other Federal, State, and local agencies were also used in the report. The report considers the quality characteristics of the waters as they exist today and trends in recent years. It evaluates the effects of waste discharges on water uses, and summarizes the principal problems and needed corrections.

The cooperation of the water resource and public health agencies of the States of Michigan, Indiana, Ohio, Pennsylvania, and New York; county and municipal agencies; and universities throughout the Lake Erie drainage basin, is gratefully acknowledged.

The report is in three parts: Part 1 is concerned with the Lake; Part 2 is concerned with the Michigan, Ohio, and Indiana tributary area; and Part 3 with the Pennsylvania and New York area.

III - DESCRIPTION OF AREA

General Description

Lake Erie is the oldest, southernmost, and warmest of the Great Lakes. It is by far the shallowest, and the only one with its entire water mass lying above sea level. Lake Erie contains the smallest volume of water; it is the most turbid; it is subject to the widest fluctuations in water level; it has the flattest bottom; and it undergoes the most violent wave activity. In recent years it changed rapidly in chemistry and biology.

Lake Erie (Figure III-1) is approximately 240 miles long with its long axis oriented at about N 70° E. It is more than 50 miles wide near the mid-point of its long axis. The Lake covers an area of 9,940 square miles, and contains a total water volume of approximately 113 cubic miles.

Figure III-2 shows the topography of the Lake Erie bottom, with a 20-foot contour interval, as interpreted from U. S. Lake Survey charts and soundings made by the Ohio Division of Geological Survey.

Topographically, Lake Erie is separated into three basins. The relatively small shallow western basin is separated from the large, somewhat deeper, flat-bottomed central basin by a rocky island chain. The relatively deep, bowl-shaped eastern basin is separated from the central basin by a low, wide sand and gravel ridge near Erie, Pennsylvania. The average depth of the western basin is 24 feet, the central basin 60 feet, and the eastern basin 80 feet.

The water in the western basin is the most turbid. It is less turbid in the central basin and is usually very clear in the eastern basin.

Hydrology

One method of describing the hydrology of Lake Erie is the water budget. This method involves the accounting of all water, incoming and outgoing, such as inflow and outflow by the rivers, supply from underground storage, overwater precipitation, and variation in water storage in the Lake. This can be formulated for a given period of time by the equation: $P + R + I - E = O$, where P = overwater precipitation, R = drainage area runoff, I = inflow from upper lakes, S = change in lake storage, E = evaporation, and O = outflow from Lake Erie. The supply from underground storage is considered to be a part of runoff, but it is considered negligible as a direct supply to the Lake.

Precipitation and streamflow records made since 1937 provide the basis for calculation of the water budget in this report. Precipitation on the Lake surface is a direct contribution to its water supply and the Lake level is affected immediately. Average annual precipitation over the Lake has been estimated at 34.6 inches.

Surface runoff from the drainage area enters the Lake via the many tributary rivers or by direct runoff from the shore areas. Average annual runoff since 1937 has been estimated at 21,000 cfs, equivalent to 29.1 inches of water over the Lake's surface, and to 35 percent of the overland precipitation.

Nearly 90 percent of the total inflow to Lake Erie comes from the Detroit River, the drainage outlet for Lake Huron. The average annual inflow, as measured by the U. S. Lake Survey near the head of the Detroit River, is 182,000 cfs, equivalent to 251 inches of water on Lake Erie.

The outflow from Lake Erie is through the Niagara River at Buffalo and the Welland Canal diversion at Port Colborne. Combined outflow

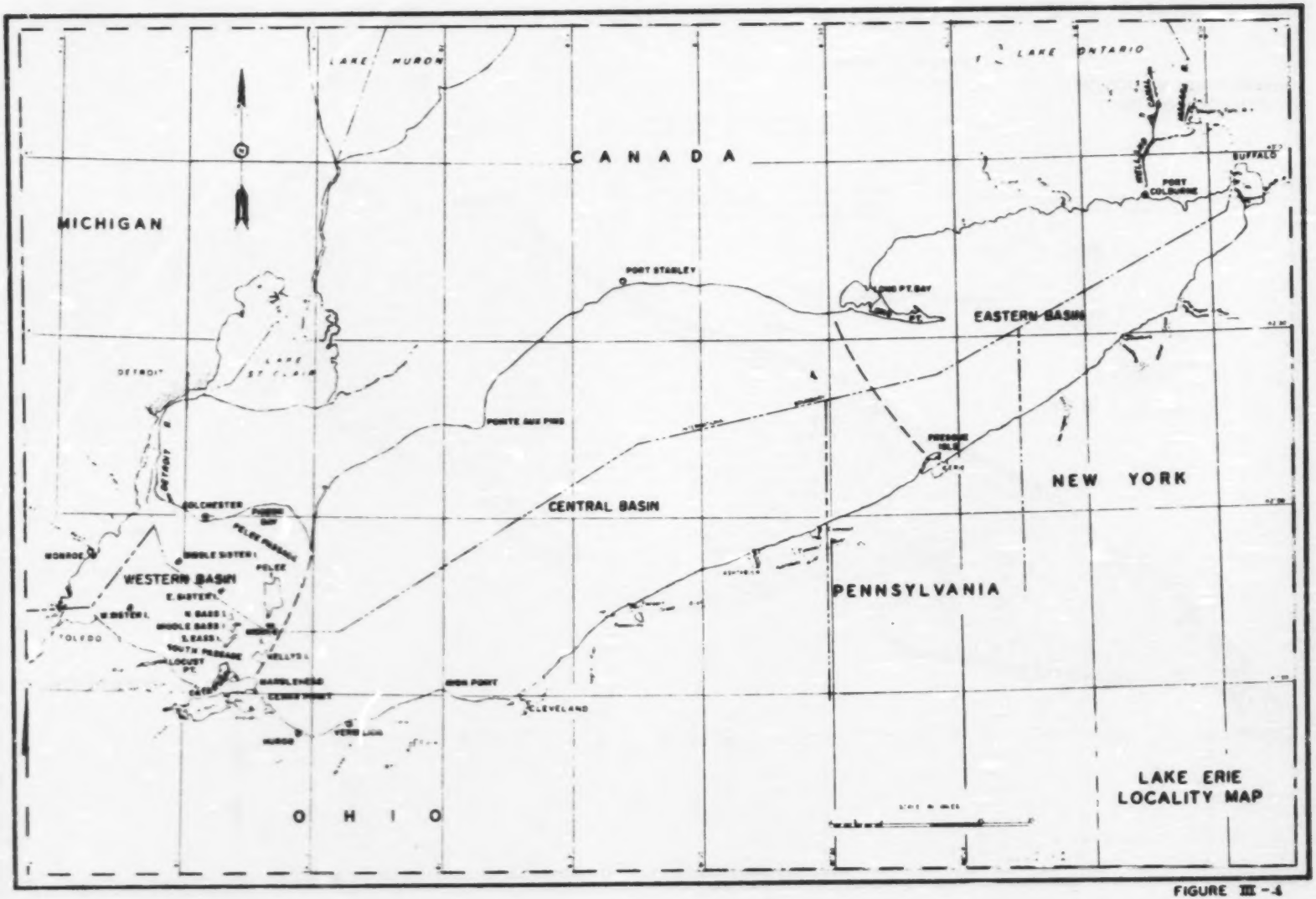
LAKE HURON
LAKE ONTARIO
CANADA
MICHIGAN
PORT STANLEY
EASTERN BASIN
BUFFALO
PORT COLBORNE
DETROIT
LAKE ST. CLAIR
POINTE AUX PINS
PRESQUE ISLE
NEW YORK
CENTRAL BASIN
COLCHESTER
PELEE PASSAGE
PELEE
MONROE
MIDDLE SISTER I.
WESTERN BASIN
E. SISTER I.
W. SISTER I.
N. BASS I.
MIDDLE BASS I.
S. BASS I.
SOUTH PASSAGE
TOLEDO
LOCUST PT.
KELLEYS I.
MARBLEHEAD
CEDAR POINT
HURON
VERMILION
HURON POINT
CLEVELAND
PENNSYLVANIA
OHIO
LAKE ERIE
LOCALITY MAP

FIGURE III - 4

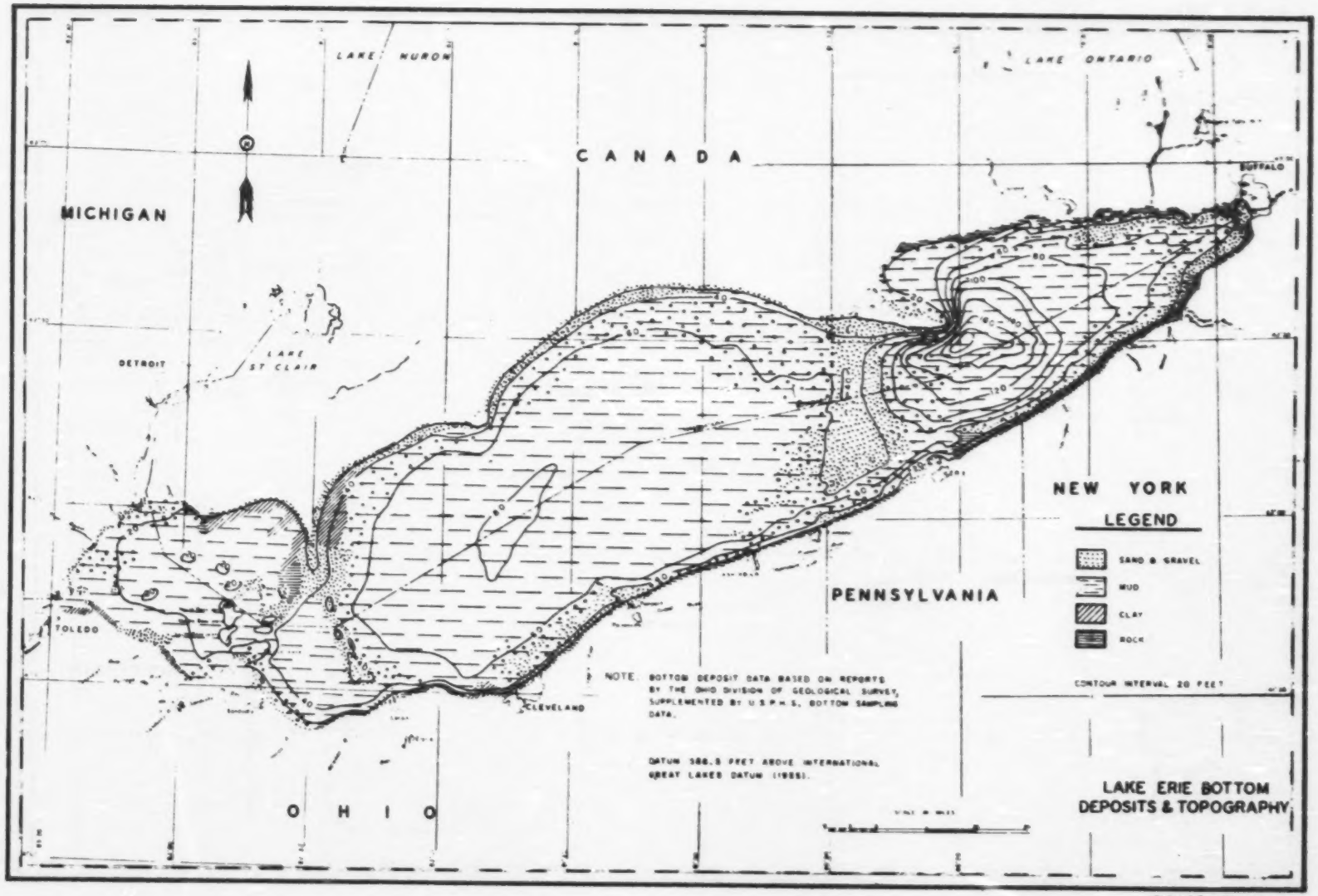
LAKE HURON
LAKE ONTARIO
CANADA
MICHIGAN
BUFFALO
DETROIT
LAKE ST CLAIR
NEW YORK
PENNSYLVANIA
TOLEDO
CLEVELAND
OHIO
LEGEND
SAND & GRAVEL
MUD
CLAY
ROCK
CONTOUR INTERVAL 20 FEET
NOTE: BOTTOM DEPOSIT DATA BASED ON REPORTS BY THE OHIO DIVISION OF GEOLOGICAL SURVEY, SUPPLEMENTED BY U.S.P.H.S. BOTTOM SAMPLING DATA.
DATUM 568.6 FEET ABOVE INTERNATIONAL GREAT LAKES DATUM (1955).
LAKE ERIE BOTTOM DEPOSITS & TOPOGRAPHY

FIGURE III - 2

averages about 202,000 cfs annually, equivalent to 279 inches of water on Lake Erie. Seasonally, both inflow and outflow are generally higher in the early summer and lower in the winter.

Annual evaporation from the Lake surface averages 33.5 inches. The low evaporation season extends from January through June, and the high evaporation season is from July through December.

The variations of Lake level on an annual basis are small, though on a monthly basis they may be relatively large. The average annual change in Lake storage in the period 1937-1959 has been insignificant and it is therefore unimportant in the computations of an average annual water budget.

Lake Currents

The net movement of water in Lake Erie is from west to east draining into Lake Ontario via Niagara River. Figure III-3 shows the generalized flow pattern within the upper 30 feet.

More than 90 percent of the input to Lake Erie is from the Detroit River. Most of this flow comes down the center of the River, fanning out continuing far southward into the western basin. The flow along the west side of the river continues along the Michigan shore to mix with the Maumee River discharge. This flow then continues eastward along the Ohio shore. The flow along the east side of the Detroit River moves eastward along the Canadian shore.

The western basin water mixes in the island area and most of it then drains into the central basin via Pelee Passage. Studies show a dominant flow toward the west in the southern channels creating an essentially rotary movement in the island area.

The drainage from Pelee Passage appears to reach as far south as the Ohio shore at least at the surface. However, much of the flow turns eastward before reaching that far south, as shown in Figure III-3.

The predominant eastward flow in the central and eastern basin is reinforced by prevailing winds from the southwest, however, wind studies for a 10-year period for Lake Erie indicate that the reversed pattern of flow may occur nearly 25 percent of the time.

Discharges from tributary streams along the south shore such as the Huron, Vermilion, Black and Cuyahoga Rivers, and other streams to the east in Ohio, Pennsylvania, and New York, tend to stay along the south shore and move normally eastward with an alternate, but smaller secondary flow to the west. General dispersal of the flows from the south shore streams with the deeper off-shore waters is limited.

The discharge of wastes and the tributary streams along the south shore of the lake will increasingly contribute to the pollution of

beaches and other water uses as it moves along the shore, both from Ohio waters into Pennsylvania and to a lesser extent from Pennsylvania to Ohio. This along shore flow will also apply to the movement of tributary streams and wastes from Pennsylvania to New York and to a lesser degree from New York to Pennsylvania.

Deep water or mid-lake circulation is complex in the central and eastern basins being controlled to a great degree by the wind. The wind induces surface flow in its general direction accompanied by an opposing subsurface flow into the wind. Since south-west winds prevail, the surface flow is dominantly toward the east and the subsurface flow is dominantly toward the west over most of the central and eastern basins. A wide band along the Canadian shore, as wide as about 1/3 of the lake's width, moves predominantly eastward from top to bottom. These phenomena are shown in Figure III-4 at stations 6 and 7. Figure III-4 shows the frequency of direction of flow and total flow at a depth of 30 feet for the summer of 1964. The net movement is from east to west at station 6, at station 7 the net flow is toward the east.

It is apparent fror these studies that discharges anywhere along the shores of Lake Erie can affect water quality in Lake Erie, with the dominant effect occuring from west to east.

Population

The 1960 census shows that approximately 10 million persons live in the U. S. portion and 1.2 million persons live in the Canadian portion of the Lake Erie basin. This is almost three times the 1910 population. Population of the U. S. portion of the basin is expected to double within the next 50 years. Although this overall rate of growth is comparable to the extimated national growth rate, past and estimated future growth rates show great differences within the watershed. Between 1940 and 1960 many economic subregions, and the counties which comprise them, have shown rapid growth rates. Almost 80 percent of the population is evenly divided between Michigan and Ohio.

Counties which have shown the most rapid growth rates during the 1950-1960 decade include Macomb and Oakland counties in Michigan, and Lake and Geauga counties in Ohio. In terms of actual numbers, however, the largest increases were in Oakland, Macomb, and Wayne counties in Michigan; Allen county in Indiana; Erie county in New York; and Cuyahoga, Summit, Lorain, and Lucas counties in Ohio. These nine counties of the total of 45 in the basin accounted for 50 percent of the 1950-1960 increase in population. Present indications are that these large metropolitan counties will account for an even greater share of the total population of the basin in the future.

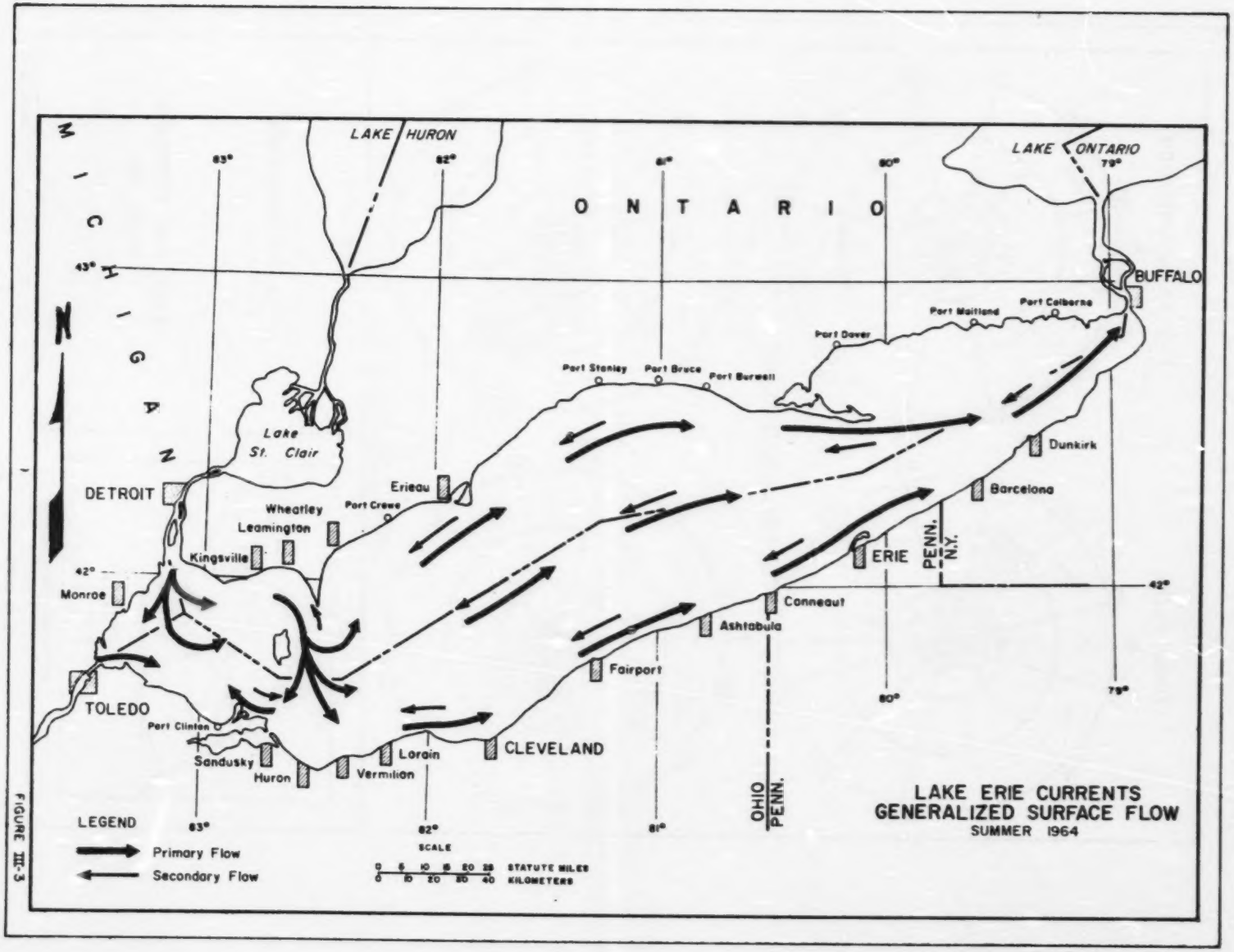
LAKE HURON
LAKE ONTARIO
ONTARIO
MICHIGAN
BUFFALO
Port Maitland
Port Colborne
Port Dover
Port Stanley
Port Bruce
Port Burwell
Lake St. Clair
DETROIT
Erieau
Wheatley
Port Crewe
Leamington
Kingsville
Monroe
Dunkirk
Barcelona
ERIE
PENN. N.Y.
Conneaut
Ashtabula
Fairport
TOLEDO
Port Clinton
Sandusky
Huron
Lorain
Vermilion
CLEVELAND
OHIO PENN.
83°
82°
81°
80°
79°
43°
42°
LEGEND
Primary Flow
Secondary Flow
SCALE
STATUTE MILES
KILOMETERS
LAKE ERIE CURRENTS
GENERALIZED SURFACE FLOW
SUMMER 1964

FIGURE III-3

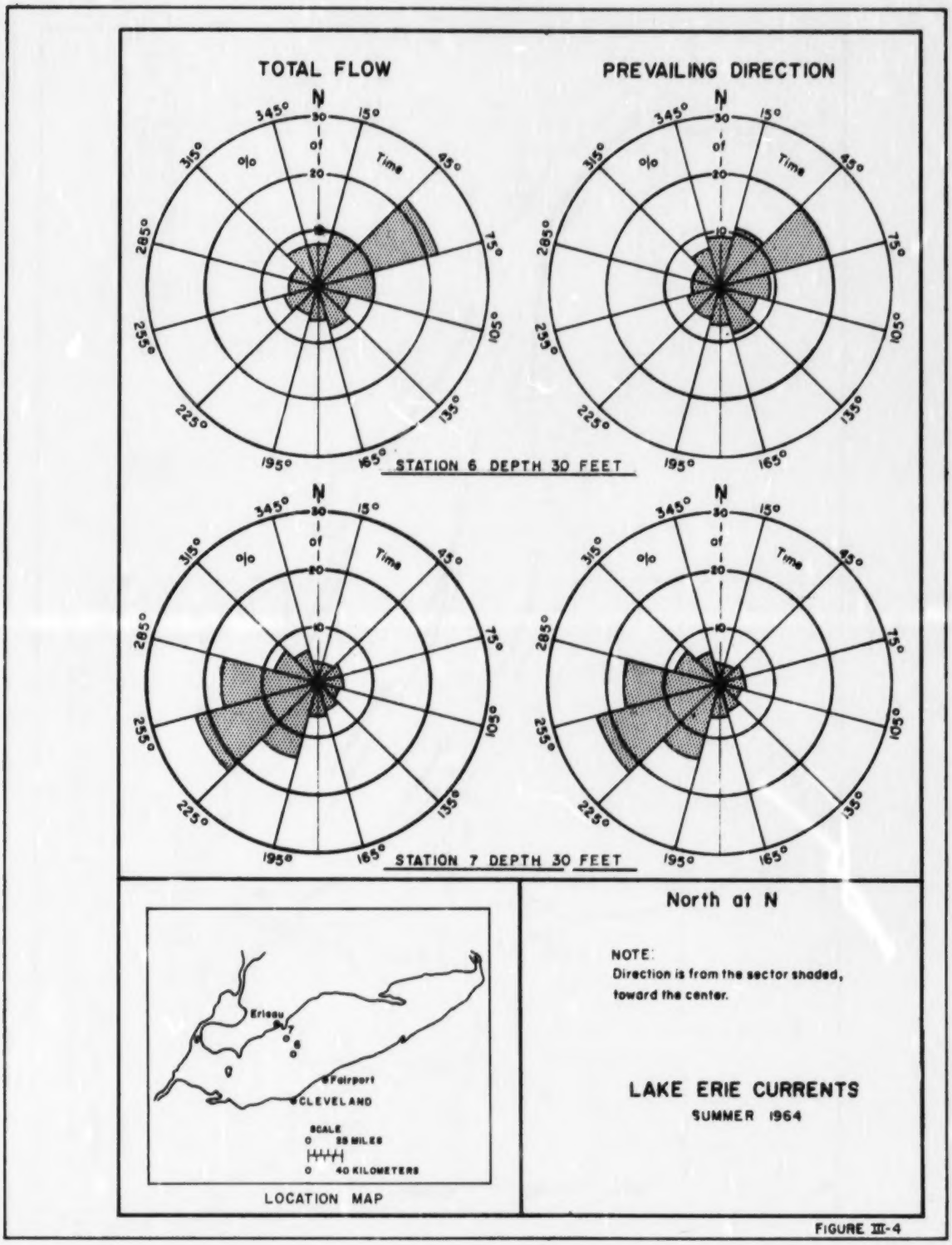
TOTAL FLOW
PREVAILING DIRECTION
N
345°
15°
315°
45°
285°
75°
255°
105°
225°
135°
195°
165°
30
20
10
%
Time
STATION 6 DEPTH 30 FEET
STATION 7 DEPTH 30 FEET
Erieau
Fairport
CLEVELAND
SCALE
0 25 MILES
0 40 KILOMETERS
LOCATION MAP
North at N
NOTE:
Direction is from the sector shaded, toward the center.
LAKE ERIE CURRENTS
SUMMER 1964

FIGURE III-4

Economics

Industrial activity as measured by value added by manufacture, although occurring in substantial volume in most counties, is for the most part highly concentrated in a few metropolitan areas. The leading counties in 1958 were: Wayne, Michigan; Cuyahoga, Ohio; Erie, New York; Summitt, Ohio; Lucas, Ohio; and Oakland and Macomb, in Michigan, in the order listed. These seven counties in 1958 accounted for 75 per cent of the total value added by manufacture in the entire watershed. Manufacturing is even more concentrated in a small group of counties than is the population. Whereas the total population of the watershed will more than double by the year 2020, industrial activity may increase six or seven-fold. Unless industries show a reduction in net water use per unit of production, industrial water requirements and possible waste returns will account for a much larger percentage of the total water used and waste returns in future decades.

The dominant industries in the largest metropolitan areas in this highly industrialized region are as follows:

Detroit - Automotive and related industry, steel, chemicals, pulp and paper, petroleum refining, and rubber.

Toledo - Automotive, glass, petroleum refining, and steel.

Cleveland - Steel, steel fabricating, automotive, and chemical.

Erie - Pulp and paper, and general manufacturing.

Buffalo - Steel, chemical, automotive, pulp and paper, Portland cement, flour milling, and electrical equipment.

Importance of Lake Erie as a Water Resource

Municipal Water Supply

Lake Erie is used as a source of municipal water supply by 27 waterworks serving many municipalities. These municipal systems serve more than 3.2 million people, and a number of industrial firms, with some 619 million gallons a day.

A summary by states showing the number of municipalities, population served, and estimated water usage is given below. The Ohio portion of the basin accounts for about two thirds of the use.

Municipal Water Supply
Lake Erie

State	Number of Waterworks	Estimated Population Served	Estimated Water Usage mgd
Ohio	16	2,239,000	409
Michigan	2	23,000	3
Pennsylvania	1	160,000	44
New York	8	835,000	163
	27	3,257,000	619

Industrial Water Supply

Industries use an estimated 4.7 billion gallons of water daily from Lake Erie. As the tabulation below shows, power production (cooling water) accounts for some 80 per cent of the industrial withdrawals. Water used for other industrial cooling accounts for approximately 15 per cent. Approximately 100 mgd is withdrawn directly by industries as process water. In addition, an unknown amount of industrial process water is obtained from municipal supplies.

Industrial Water Supply
Lake Erie

State	Total Withdrawal (mgd)	Amount Used for Power (mgd)	Amount Used for Cooling (mgd)
Ohio	2,210	1,920	270
Michigan	337	190	2
Pennsylvania	170	140	20
New York	2,020	1,600	350
	4,737	3,850	642

Lake Erie Commerce

Lake Erie is fourth in size of the five Great Lakes, but its total freight tonnage of 107.5 million tons was second only to that of Lake Huron in 1962.

The domestic shipping in 1962 on Lake Erie was 74.7 million tons, or 70 per cent of the total tonnage. Domestic shipping included all commercial movements between points in the continental United States. The foreign shipping (93 per cent Canadian) was 32.8 million tons, 30 per cent of the total. In ton-mileage, Lake Erie accounted for 12.6 billion ton-miles.

Lake Erie has eleven major U. S. ports: Toledo, Detroit, Cleveland, Buffalo, Ashtabula, Lorain, Sandusky, Conneaut, Fairport, Erie, and Huron. During the period from 1953 to 1962, eight of these ports have shown a decline in total tonnage. In 1964, the Corps of Engineers dredged about 3.3 million cubic yards from Lake Erie ports at a cost of about $1.2 million for routine maintenance of the navigation channels.

Recreation

Lake Erie does not have big, wide sand beaches. Good beaches are at Catawba Island; Cedar Point at Sandusky; and Erie, Pennsylvania. These highly developed recreational areas attract thousands of people each year. The beaches in most other areas are relatively narrow. Some cities, such as Cleveland, have provided man-made beaches to serve the people in the area.

Lake Erie is used extensively for other recreational purposes such as fishing and boating. There are many boat launching ramps along the lakeshore, which serve people from a wide area. There are a large number of boats that are trailered to various sites each weekend, many from outside the area. Due to this fact, it is difficult to determine exactly how many boats are actually using the Lake. However, a fair estimate can be made by totaling the boats registered in the counties near the Lake. This is the basis for the second column in the tabulation below.

State	Total State Boat Registration (1964)	Estimated Number Using Lake Erie
Ohio	142,922	73,000
Michigan	362,112	79,000
Pennsylvania	78,359	6,000
New York	335,000*	34,000
	918,393	192,000

*Estimate made by State of New York, Department of Conservation.

Fish

Commercial fishing has been practiced in Lake Erie for more than a century and a half. It has always produced more fish and a greater variety of fish than the other Great Lakes, but the species composition has varied greatly, and the annual harvest has diminished. Lake herring practically vanished around 1890, and whitefish have declined greatly

since about 1920. Lake trout, which never reached great numbers, are practically non-existent today. The blue pike, a highly desirable species, declined from a peak annual U. S. catch of 20 million pounds in 1936 to a meager 7,400 pounds in 1960. Sauger also declined sharply from a U. S. catch of about 6 million pounds in 1916 to almost none in 1960.

The importance of sport fishing in Lake Erie is reflected in the numbers of fishermen and in the annual harvest of sport fishes. In the counties bordering Lake Erie, more than one-half million fishing licenses were issued in 1964. Presumably, a good many of those people fish in Lake Erie. According to a 1964 report by the Ohio Department of Natural Resources, boat anglers in 1960 harvested 1,300,000 pounds of fish. During that year, the Ohio commercial catch was 1,290,000 pounds. Species that predominated the sport harvest were yellow perch, sheepshead, white bass, small-mouth bass, channel catfish, and walleyes. The highest intensity of sport fishing was in the island area. Fishing pressure is also heavy in the Michigan and Pennsylvania waters.

IV - DEGRADATION OF LAKE ERIE

Lake Enrichment

Eutrophication means enrichment of waters through either man-created or natural means. Natural enrichment produces a rate of lake aging that may be manifested only on the clock of geologic time. Additional fertilization will accelerate the rate of lake aging, making changes in water quality noticeable within a decade or even less. For example, growing cities and expanding industries are pouring nutrients into the nation's waterways at an ever-increasing rate, and aquatic weed and algal nuisances are occuring in areas where they did not exist before.

The scope of accelerated eutrophication or water enrichment is broad and the ramifications are many. The most perceptible characteristics to the layman include nuisance growths of small suspended plants or algal scums, developing areas of rooted water plants, and odors associated with decaying dead vegetation and possibly fish. More subtle changes can be found by the investigator as indicated by decreased light penetration; decreased dissolved oxygen in deeper waters; increased nitrogen and phosphorus concentrations especially in the deeper waters; significant changes in the algal population, and in the kinds and numbers of bottom dwelling organisms, and increased rooted aquatic weed beds.

There are many elements that are essential to life processes. Among these are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulfur, and several trace minerals. They are all present in sewage. Nitrogen and phosphorus is partially removed by a sewage treatment plant, but the percentage of removal depends on plant design and efficiency of operation. Nitrogen is in good supply from natural sources (80% of the air we breathe is nitrogen), but phosphorus is not plentiful. The density of algae growth is usually governed by the concentration of phosphorus. If phosphates are reduced, algae growths are correspondingly less. Phosphorus, a constituent of domestic sewage and certain industrial wastes, promotes algae growths and is thus a serious pollutant that must be controlled.

It is well documented that many lakes throughout the country have been fertile reservoirs for algal development for many years and have been labeled eutrophic. Included among these are Lake Zoar in Connecticut, Lake Sebasticook in Maine, the Madison lakes in Wisconsin, Lake Erie, the Detroit lakes in Minnesota, Green Lake and Lake Washington in Washington, and Klamath Lake in Oregon. Of these, Lake Erie is the largest.

When the concentrations of inorganic nitrogen and soluble phosphate exceed 0.3 mg/l and 0.03 mg/l, respectively, prior to the algal growing season and when other growth conditions such as light, temperature, and turbulence are favorable, algal blooms have been found to develop. Those algae that occur usually in small numbers in infertile lakes become supplanted by larger populations of more troublesome kinds.

As nutrient concentrations increase, the numbers of algal cells increase. Nuisance conditions such as surface scums and algal-littered beaches occur. The water may become foul-smelling. Filter-clogging problems may occur at municipal water supplies. Filamentous algae, especially Cladophora, grow profusely on almost any suitable subsurface. They, too, cause nuisance conditions when they break loose and wash ashore at bathing beaches to form windrows of stinking vegetation. Growths of filamentous algae and slimes hamper commercial fishing by adhering to nets, and interfere with municipal and industrial water supplies by clogging intake screens.

At this stage of eutrophication other changes are occurring in the lake. The bottom is changed by sedimentation of organic material; this habitat is changed from one suitable for mayfly nymphs, scuds and other small organisms favored as food by desirable fish to one where only sludgeworms and bloodworms can exist. Fish populations are changed to the coarser species because the habitat is more favorable to them.

Nutrient concentrations in Lake Erie indicate that soluble phosphate values in the western basin consistently exceeded the stated critical value during studies in 1963 and 1964, with average concentrations ranging from 0.05 to 0.15 mg/l phosphate (PO_4). The central and eastern basins now have phosphate concentrations at the critical threshold value and any increase in present levels will produce a corresponding increase in algal populations.

Water clarity as demonstrated by Secchi disc readings indicates that visibility of the white and black disc extends through 4 feet in the western basin, and through 13 feet in both the central and eastern basins. Because this test measures relative turbidity conditions by a combination of algae and other suspended material, it reflects undesirable changes in the western basin.

The biology of the western Lake Erie basin has changed drastically during the past 35 years, especially the past 15. In the Bass Island area, samples collected in September 1964, showed suspended algal populations of 3,500 organisms per milliliter (about 3.5 million per quart) compared to a maximum 1,000 per milliliter found in a study conducted between 1938 and 1942. Species composition has also changed from one predominantly of diatoms to one presently dominated by blue-green algae that are associated closely with enriched waters.

Long-term increases in suspended algal populations are also apparent from data published for the area adjacent to Cleveland in the central basin of Lake Erie. Annual averages have increased from 200 to 400 cells per milliliter between 1920 and 1930 to 1500 to 2300 cells at the present time. Also, there have been significant changes in dominant organisms with blue-green algal forms becoming increasingly present even in this area.

Although historical data are not available for the suspended algae of the eastern basin, PHS studies in 1963 and 1964 revealed that the kinds and numbers are similar to those that occurred in the central basin.

The filamentous green alga Cladophora is encouraged by enriched waters to grow on any suitable attachment site. When it matures, it characteristically breaks loose, floats to the water surface, and creates an odorous nuisance when deposited on beaches by wind and waves. An estimated 340 miles of Lake Erie shoreline has a subsurface suitable for Cladophora growth. Nuisance conditions have become so severe that restricted swimming and sunbathing have occurred in the island area and at the beaches in the eastern basin, especially east of Erie, Pennsylvania and near Dunkirk, New York.

A survey of Lake Erie bathing beaches was made in 1964 to determine their present use. As the tabulation below shows, 21 of the 32 beaches contacted reported that they were open.

BATHING BEACHES
LAKE ERIE

Area	Status - 1964
21	Open
6	Open-closed intermittently
3	Closed
1	Open but posted unsafe
1	Open - high coliform counts observed

At six beaches, it has been found necessary to restrict swimming for short periods during and following rains and high winds owing to an increase in microbiological pollution. Beaches of this type are classified "open intermittently."

The three beaches that are closed are at Toledo and two areas in New York. The beach at Sterling State Park, Michigan, was reported open but posted as unsafe for bathing.

The four groups of bottom-dwelling animals that occur abundantly in Lake Erie include sludgeworms, bloodworms, and fingernail clams, all of which are found in a lake bed covered by decaying organic ooze; and scuds which prefer a relatively clean lake bed. Of the four groups, scuds are preferred as food by the more desirable fish species. Although all of these organisms were found in all three basins of Lake Erie there was a difference in the relative abundance of each.

In the western basin, sludgeworms and bloodworms were predominant in three large areas. One area extended from the Detroit River mouth southward for more than ten miles. Another fan-shaped area extended from the mouth of the Maumee River for a distance of ten miles. The third area extended about 4 miles lakeward from the mouth of the River Raisin.

Sludgeworms, bloodworms, and fingernail clams predominated in the bottom populations in almost the entire western two-thirds of the central basin. In the eastern third of the central basin, as in the eastern basin, scuds were the predominant animals.

These present conditions are in sharp contrast to the kinds of bottom-dwelling organisms that occurred in the western basin in past years. Prior to 1953 burrowing mayfly nymphs were by far the predominant bottom organisms. In September 1953 the western basin became thermally stratified and dissolved oxygen was depleted in the deeper waters. Great numbers of mayflies were killed. Although some areas were re-populated by mayflies in 1954 the overall distribution of these important fish food organisms declined year by year, and by 1959 only a few organisms could be found. During this same period the caddisfly, another desirable fish food organism, virtually disappeared from the deeper waters surrounding the islands. In both instances sludgeworms and bloodworms have supplanted the mayflies and caddisflies as the predominant bottom-dwelling animals. Restoration of mayfly and caddisfly population will not be possible as long as periodic deleterious dissolved oxygen conditions occur. The above biological evidence indicates a general degradation of conditions in Lake Erie from east to west, reflecting the major influence of the large sources of waste at the west end of the Lake.

Dissolved Oxygen Deficit in the Bottom Waters

Low dissolved oxygen concentrations were detected in the bottom waters of the central basin as early as August 1929 when DO values of 4.4 and 4.8 mg/l were recorded at 2 stations in the central basin. A low value of 0.8 mg/l was measured at one station near Marblehead, Ohio, in August 1930.

Low DO values from 1948 through 1951 of 2 to 4 mg/l were recorded and in September 1959 the DO was found to be less than 3 mg/l in a large area of the central basin. A survey in August, 1960 revealed a similarly large area where the DO was less than 3 mg/l. One zero DO was recorded in August 1959 near the south shore.

In August 1964, an area of about the same magnitude was found where the DO concentrations were even lower (Figure IV-1). Most of the affected area had DO values of 2 mg/l or less. This area was about 2,600 square miles, or about 25 per cent of the entire Lake.

In summary, dissolved oxygen values in the bottom waters of the central basin of Lake Erie appear to have decreased during the past 35 years from about 5 mg/l to less than 2 mg/l, with many parts near zero.

This DO deficit is caused largely by lake enrichment. When this is coupled with a physical phenomenon called thermal stratification, the mechanism is established through which oxygen is consumed in the bottom waters. As explained earlier, the lake is enriched by the introduction of such materials as nitrogen and phosphorus that encourage plant growth.

Thermal stratification occurs when the upper layer of lake water becomes one temperature, a lower layer of water becomes a different temperature, and a third layer of water called the thermocline is sandwiched between them. The thermocline is the layer where a sharp temperature differential exists.

During summer stratification, the upper water layer is as much as 16°C higher than the bottom layer. Almost all lakes stratify thermally, but dissolved oxygen deficits occur only in those lakes where large amounts of oxygen-consuming materials and nutrients have been introduced. These materials may be introduced directly as sewage or certain industrial wastes, or indirectly by nutrients that accelerate algal growth. Suspended organic materials are scattered over a wide area by winds and lake currents, settle to the bottom, and exert an oxygen demand during decay. The crop of suspended algae that grow in great numbers in a fertile lake is ever changing. Cells die off and settle slowly to the bottom. During their descent, they are attacked by decay organisms and exert an oxygen demand. Thus, in a fertile lake, oxygen is being removed by the bottom muds and by the suspended organic matter in the water above. Lake Erie is susceptible to damage from these happenings, especially in its central basin.

The western basin does not become stratified except during 6 to 7 day periods of calm because it is so shallow that wind-induced turbulence creates thorough mixing from surface to bottom.

Both the central and eastern basins do become stratified, usually from June to October. A serious dissolved oxygen deficit does not develop in the eastern basin because it is much deeper than the central basin. The thermocline, or middle layer of water, lowers in the central basin as stratification becomes well established until it is about 50 feet below the surface. At this time, the lower layer of water in the central basin becomes thin, on the order of 8 to 10 feet thick. At the same time, the eastern basin, which is about 150 feet deep, may have a bottom layer 100 feet thick.

The central basin is adjacent to the western basin where there are large inputs of wastes and where the heaviest growths of suspended algae occur. The overall easterly movement of water may carry some of this material to the quieter waters of the central basin where it settles to the bottom.

Changes in the Fishery

Dramatic changes have occurred in the Lake Erie fishery. Although Lake Erie is still the most productive of all of the Great Lakes, the quality of the catch is low. The only high quality fish still abundant is the perch. Blue pike have disappeared, and herring and whitefish are scarce. The Michigan Conservation Department, in a statement presented at the Detroit River-Lake Erie Water Pollution Conference on June 17, 1965, summed up the Lake Erie fishery situation as follows:

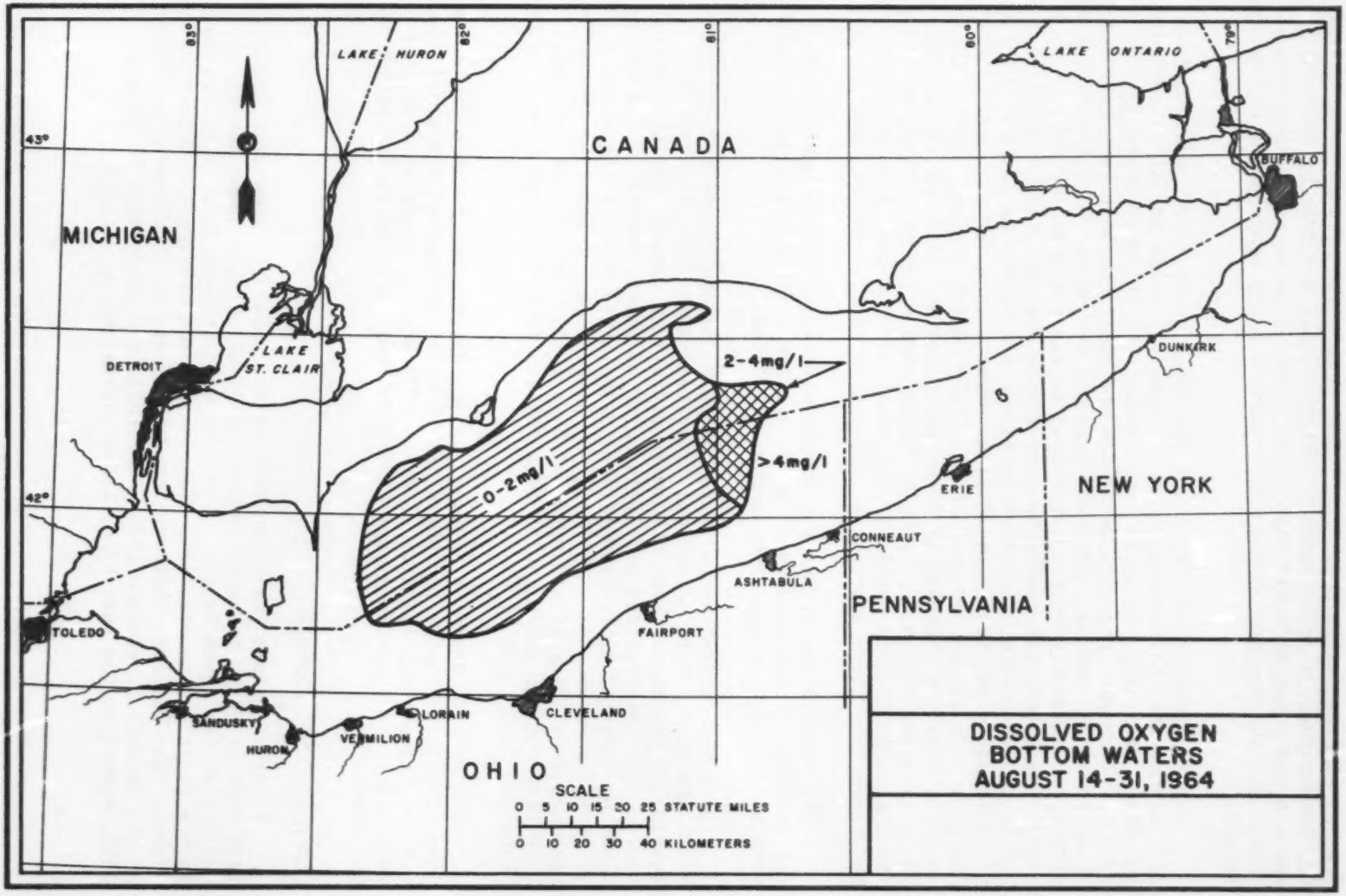
LAKE HURON
CANADA
LAKE ONTARIO
BUFFALO
MICHIGAN
DETROIT
LAKE ST. CLAIR
2-4mg/l
0-2mg/l
>4mg/l
DUNKIRK
ERIE
NEW YORK
CONNEAUT
ASHTABULA
PENNSYLVANIA
TOLEDO
FAIRPORT
SANDUSKY
HURON
VERMILION
LORAIN
CLEVELAND
OHIO
SCALE
0 5 10 15 20 25 STATUTE MILES
0 10 20 30 40 KILOMETERS
DISSOLVED OXYGEN
BOTTOM WATERS
AUGUST 14-31, 1964

Figure IV-1

"The evidence is strong that the deterioration of fish resources in these waters has come about principally because of the environmental changes resulting from pollution. These changes are complex and subtle, and have affected fish life in many ways. Perhaps the most important change is rapid eutrophic aging stimulated by nitrogen compounds and phosphates found in organic wastes. Nutritive enrichment provided by these wastes leads to oxygen depletion, temperature increases, turbidity, and interruption of the biological food chain. In addition, some chemical and industrial waste toxicants directly harm fish."

and they concluded:

"The fisheries....can be saved only by an all-out effort to restore water quality to standards favorable to desirable fish."

V - WASTE INPUTS TO LAKE ERIE

Introduction

Municipal sewage and industrial wastes are the principal pollutional materials discharged continuously into the waters of Lake Erie. These waste sources, along with other sources such as land runoff; combined sewer overflow, and wastes from lake vessels; barge tows and pleasure crafts, all add to the pollution of the Lake by direct discharge or by increasing the tributary loadings of rivers draining into the Lake.

Municipal Wastes

Approximately 10 million people inhabit communities throughout the Lake Erie basin. These communities discharge their wastes directly into Lake Erie or into rivers tributary to it. Table V-1 shows the approximate unsewered and sewered populations discharging into the various rivers from each state bordering the Lake. The table also shows the degree of treatment, primary and/or secondary, received by the sewered population. Population equivalents are given and include the sewered industrial load as well as the municipal load.

In Ohio, the largest municipal waste sources are discharged either directly into the Lake or into the Cuyahoga, Maumee, or Sandusky Rivers. Of the 1.8 million sewered PE bordering Lake Erie, 1.3 million are handled by two Cleveland sewage treatment plants. The Cleveland Easterly Plant provides secondary treatment for approximately one million PE, and the Cleveland Westerly Plant provides primary treatment for some 300,000 PE. The Cleveland Southerly sewage treatment plant and Akron handle wastes from approximately one million of the 1.2 million PE discharging into the Cuyahoga River. Both plants provide secondary treatment.

The Maumee River's largest waste sources are Toledo in the Lower Maumee River area, and from Fort Wayne, Indiana in the Upper Maumee River area. The Toledo Plant provides secondary treatment for 600,000 PE, and Fort Wayne gives secondary treatment for 200,000 PE.

The Sandusky River receives wastes from municipalities whose total population is about 100,000 PE. The cities of Fremont and Bucyrus with secondary treatment serve approximately 30,000 and 18,000 PE, respectively. The city of Tiffin with primary treatment serves about 19,000 PE.

Approximately 79 per cent of the total municipal waste in Ohio-Lake Erie Basin receives secondary treatment. About 3.5 per cent of the population are not served by sewer systems.

In the Michigan basin most of the population is centered in and around Detroit. The Detroit Primary Sewage Treatment Plant serves about 3.1 million people. While 94 per cent of the Southeastern Michigan population is sewered, only 11 per cent of the total population receives secondary treatment.

In New York, the wastes from 78 per cent of the population receives primary treatment. The cities of Buffalo, Niagara Falls, and part of Tonawanda have sewage treatment plants that provide only primary treatment. These three cities serve over a million of the 1.2 million people receiving primary treatment.

The wastes from almost 100 per cent of the sewered population in Pennsylvania receive secondary treatment. The city of Erie is the largest city in Pennsylvania that discharges directly to Lake Erie and provides treatment for 173,000 PE or about 90 per cent of the sewered PE.

Industrial Pollution

Industrial waste information in this report was obtained from records of the Michigan Water Resources Commission, Indiana Stream Pollution Control Board, Ohio Department of Health, Pennsylvania Sanitary Water Board, and New York Water Pollution Control Board.

Industrial Waste Sources
State Classification

State	Inadequate	Unknown	Total
Ohio	36	9	161
Indiana	2	-	11
Michigan	19	8	76
Pennsylvania	2	2	9
New York	4	7	14
Total	63	26	271

The above tabulation shows that there are 271 known sources of industrial wastes that discharge to the Lake and tributaries. The states have classified about 23 per cent of these industries as having inadequate treatment facilities. The adequacy of an additional 10 per cent of the industries has not been determined. Table V-2 lists the total number of industries in each major subbasin. The individual industries are listed in Parts 2 and 3 of this report.

Table V-3 lists the industrial establishments that discharge directly to the Lake or to the lower rivers in the Lake-affected areas. A total of 53 industries are known to discharge in this area. This represents about 20 per cent of total industrial discharges in the basin. Of these 53 industries, 22 are reported to have inadequate treatment facilities by the State agencies.

Data have not been made available for the computation of meaningful waste loads from industries.

Inputs

The waste substances that are discharged to the Lake from municipal and industrial outfalls, tributaries, and land drainage are many, and their effects on water uses are varied. Many substances such as acid, oil, cyanide, iron, phenol, and oxygen consuming materials have severe effects on water uses in the localities of the discharge. These will be dealt with in discussions of local water use problems and damages.

These substances that have damaging effects on the water use of the total waters of the Lake are suspended solids (sediment), carbonaceous oxygen consuming materials, nitrogen compounds and soluble phosphate. A discussion of chlorides and dissolved solids is also included, not because they have reached damaging concentrations, but because their dramatic increases are indicative of the rate at which water quality has been degraded. Tables V-4 to V-8 present summaries of the major known inputs of these substances to Lake Erie.

Suspended Solids

Damage to Lake Erie resulting from suspended matter entering from waste discharges and tributaries are dependent on the nature and its deposition results in enriched bottom muds or sludge banks, having largely local effects. Proper treatment for removal of these wastes can correct this problem. Suspended matter from certain industries and the material from tributaries, originating as land runoff is largely inorganic and its effects on settling result in the filling of harbors, embayments, ship channels and the Lake.

The principal sources of suspended solids discharged to Lake Erie are the Detroit, Maumee, Cuyahoga and Grand Rivers which represent a total of 11,000,000 pounds per day of known discharges. The Detroit River constitutes 78 per cent of this total, the Maumee 14.5%, the Cuyahoga 4.5%, and the Grand 4%.

About 1.5 million pounds of the Detroit River discharges are from industrial and municipal sources. The Maumee discharges are largely silt originating from land runoff. The greatest quantity is released during periods of heavy rain and high runoff, therefore control must be instituted through improvements in land use practices on the watershed. The Cuyahoga sediment load includes industrial sources as well as both municipal and land runoff loads. The effects of this load on the Cleveland harbor and channels result in severe discoloration and the need for frequent dredging. The Grand River sources are similar to the Cuyahoga.

Carbonaceous Oxygen Consuming Materials

Carbonaceous oxygen consuming materials, usually measured by the 5-day biochemical oxygen demand (BOD), are usually considered direct pollutants to streams in that they depress dissolved oxygen levels. This immediate effect is not evident in lakes such as Lake Erie. However, BOD is a measure of wastes that are used by bacteria in cell growth and reproduction, thereby creating sludge which settles to the

lake bottom. Thus BOD is a measure of wastes which produce the same end effect as nutrients as discussed below. Carbonaceous BOD of wastes is most effectively removed by secondary treatment.

Chloride

The concentration of chloride averaged 7 mg/l in the headwaters of the Detroit River and 23 mg/l at Buffalo, a threefold increase. Major known sources of input are the municipal and industrial contributions at Detroit, about 3 million pounds per day, the Grand River 2.2 million pounds/day and the Maumee and Cuyahoga 1 million pounds/day.

A large input of chloride from street and highway salting for ice control during winter ultimately drains to the Lake through municipal sewers and tributaries. Salt use for this purpose in 1964 was at least 800,000 tons which represents an increase of at least 2.4 mg/l to the chloride level of the Lake water.

Dissolved Solids

Dissolved solids concentrations at the head of the Detroit River average 126 mg/l and at Buffalo 192 mg/l.

The concentration of dissolved solids in Lake Huron has increased from 110 mg/l in 1900 to 115 mg/l at present, whereas the increase in Lake Erie at Buffalo in the same period was from 115 to 192 mg/l.

Nitrogen Compounds

The major known sources of nitrogen compounds entering Lake Erie are listed in Table V-7. The largest input is the Detroit River, which consists of the nitrogen residual from the upper Great Lakes and the contributions from the Detroit metropolitan area. Other major sources are the Maumee and Cuyahoga Rivers and the industrial and municipal discharges at Toledo and Cleveland.

The origin of these nitrogenous materials is largely from organic wastes, with sizeable contributions from specific manufacturers of ammonia and nitrogen salts. Except for local effects of discharges of these materials, the principal effect on Lake Erie is that of fertilization. Both nitrogen and phosphate are critical materials in the control of lake fertilization, however the nitrogen compounds are less amenable to control partly because control methods are not fully developed and partly because conversion of nitrogen from the air by some aquatic organisms can provide sufficient nitrogen to support algal growth. For these reasons, the abatement of pollution from lake fertilization through phosphate control provides greater potential for success than control of nitrogen inputs. However, the institution of secondary treatment will significantly reduce nitrogen inputs and thereby aid in the control of local problems as well as reduction in total inputs to the Lake.

Soluble Phosphate

Phosphorus, in its inorganic form of orthophosphate (PO_4) is an essential element of biological life. It is used extensively as an agricultural fertilizer. All animals and plants require phosphate for normal growth and reproduction.

Because phosphate is so important to biological life it can become a controlling factor in the rate of growth or size of crop, and under conditions of limited abundance as prevails in Lake Erie it is the one factor most easily controlled.

The pollution caused by phosphate in Lake Erie results in uncontrollable production of algae followed by decay of this organic matter produced in the Lake. The decay, in turn produces zones of oxygen depletion, as has been evidenced by studies in the past and the recently revealed zone of serious oxygen depletion of 2600 square miles of the central basin. The productivity and decay that caused this tremendous loss of oxygen was of massive proportions. In 1964 it produced an oxygen deficit estimated at 270,000,000 pounds. The total of all oxygen consuming wastes from man-made sources now entering the lake is only a small portion of the oxygen demand causing this deficit.

Phosphate inputs from principal sources are presented in Table 8. Of the total of 174,000 pounds of soluble phosphate discharged from known sources daily, 67 per cent is from municipal and industrial sources discharging directly to the Lake, and 33 per cent from tributaries (including the St. Clair River), and other small sources. The St. Clair River input is 6.8 per cent of this total. All other sources are amenable to some degree of control.

A 65 per cent reduction of phosphate inputs can be achieved through secondary sewage treatment, operated to effect optimum phosphate removal. Secondary treatment provides additional benefits through greater reduction of oxidizable organic matter, disease-causing organisms, phenolics, nitrogen, and other waste materials.

The major controllable sources and the amount of reduction that can be achieved by the secondary treatment described above are listed below:

Detroit	45,500 pounds per day
Toledo	2,900
Sandusky	700
Lorain-Avon	1,700
Lakewood	600
Westerly	3,500
Easterly	6,800
Euclid	1,300
Erie	1,300
	64,300
80% reduction Michigan industry	8,000
	72,300

Thus, at least 40 per cent of present PO_4 input can be reduced by secondary treatment at the principal waste sources. This alone would significantly reduce algae growths in the Lake. Therefore, the first requirement for phosphate pollution control in Lake Erie is the construction of secondary treatment plants where they do not now exist and improved treatment techniques for those plants that now practice secondary treatment.

These reductions, based on present day factors, must be constantly improved in order to account for increases in phosphate loadings resulting from population, industrial and agricultural growth.

Even with the institution of secondary treatment, and operation of treatment plants for optimum phosphate removal, the reduction in phosphate inputs will require several years, and no sudden or dramatic reductions in Lake algal productivity can be expected. Therefore, top priority must be given to the earliest construction and operation of those plants at which the highest removals can be achieved; namely Detroit, Toledo, Cleveland, and Erie. After these treatment practices are in operation it can be reasonably expected that significant improvement in the water quality in Lake Erie will be observable within a few years. At that time, the effects of these measures should be reevaluated to determine if further reduction of nutrients by additional treatment will be necessary.

VI - FEDERAL INSTALLATIONS

The Federally-owned or Federally-leased installations listed below discharge wastes to surface waters or to the ground. Installations that discharge to municipally-operated sewerage systems, with a few exceptions, have not been listed since the Federal Government does not control the kind of treatment provided. Federal installations in Michigan are not included in this report since they have been discussed in the "Report on Pollution of the Detroit River, Michigan Waters of Lake Erie, and Their Tributaries," April 1965.

GSA Materials Depot, New Haven, Indiana

Secondary treatment with ground discharge is provided for sewage from approximately 75 persons. Waste treatment facilities are adequate.

Erie Army Depot, Port Clinton, Ohio

This Army depot is scheduled to be phased out by December 31, 1966. All sewage from approximately 1,800 persons receives secondary treatment (activated sludge) and chlorination. The average dry weather discharge is 0.12 mgd. Waste waters from boiler blowdown, air conditioning, compressor cooling, plating rinse solutions, and laundry facilities are discharged to the storm sewer system. Approximately 200,000 gpd are discharged to Rusha Creek from the latter system. Because of the planned closing of this installation, no improvements will be made for handling industrial wastes from such operations as metallic plating.

The Lewis Research Center, NASA, Plum Brook Facility, Ohio

This installation, located near Sandusky, has a complement of approximately 700. A primary treatment plant with chlorination treats wastes from 400 employees; two smaller secondary package treatment plants serve the rest. Septic tanks with disposal fields serve isolated buildings on the property. Small amounts of chemical and acid wastes are collected in underground holding tanks for disposal by a contract firm.

The Lewis Research Center, NASA, Cleveland Facility, Ohio

This installation employs approximately 3,500 persons. All sewage and some cooling water are discharged (1 mgd) to the Cleveland city sewers. Cooling water from test stands and research facilities flows to two 1 MG capacity settling basins, operated on a fill and draw basis, and then to the Rocky River. Water with high chromate concentrations from intermittent cooling tower blowdown is held in the settling basins and released to the city system after dilution. Approximately 1.4 mgd of

cooling water is discharged to the Rocky River through storm sewers Owing to increased operations of both NASA and a nearby Army automotive plant, the main sanitary sewer serving both installations now has insufficient capacity to carry the entire flow during heavy storm run-off periods. This problem is currently being investigated.

Cleveland Army Tank Automotive Plant, Cleveland, Ohio

This plant located adjacent to the NASA facility described above employs approcimately 2,100 persons in engineering design and manufacture of military armored vehicles. Industrial wastes receive treatment that includes anthracite filtration, neutralization, chemical coagulation, and chlorination. Discharge to the Rocky River is intermittent depending on production. The industrial treatment plant is operating satisfactorily and is under the supervision of a qualified chemist. All sewage is discharged to a sewer which also serves the nearby NASA facility. Owing to the insufficient hydraulic capacity of this sewer to transport all wastes from the two installations to the Cleveland municipal sewerage system, a by-pass to Rocky River has been provided. By-passing occurs only during storms. The presence of storm water in the sewer is possibly due to infiltration or unknown connections at the Cleveland Airport. The problem is now being investigated.

Nike Missile Sites, Cleveland Area

Site 29C

This site has a complement of 50. All sewage is discharged to a settling tank and subsurface sand-filter. The sand-filter was rehabilitated in the fall of 1964. Approximately 3,000 gpd are discharged to the above system which now appears to be operating well.

Site 34L

Approximately 2,500 gpd of sewage are being discharged to a system similar to the one serving Site 29C. The treatment facility appears to be operating well.

Post Office, Bellevue, Ohio

The Post Office has 27 employees. Sewage (250 gpd) and some storm water flow to a concrete-block-lined cesspool on the installation's property. The system appears hydraulically adequate to handle the flow. The City of Bellevue does not have a municipal sewerage system.

Perry's Victory and International Peace Memorial National Monument, South Bass Island, Ohio

Sewage from the public comfort station located below the monument

is treated by a septic tank and drain field. The superintendent's home and the National Park Service Office at the Monument are each served by two septic tanks, and the effluent is discharged to the Put-In-Bay sewer system which discharges to Lake Erie without further treatment.

Post Office, Silver Creek, New York

Sewage from 12 employees flows to a septic tank and then to the Silver Creek storm sewer system without further treatment. The City of Silver Creek does not have a municipal sanitary sewerage system.

Air Force Plant No. 49, Buffalo, New York

This plant, owned by the U. S. Air Force, is operated under contract by the Metal Processing Division, of Curtis Wright Corporation. All sewage, 5,300 gpd, is discharged to the Buffalo City System. About 60,000 gpd of cooling water is discharged directly to the Scajaquada Creek. The cooling water does not contain wastes from processing. Waste disposal practices appear adequate.

Nike Sites, Buffalo Area, New York

Many of the Nike missile sites in this area have been phased out and are now operated by the New York National Guard.

Site 41

Approximately 500 to 1,000 gpd of sewage is treated by a 1,000 gallon septic tank and sand-filter with post chlorination. The two original two-stage biofiltration units at this installation are not being used due to the insufficient flow.

Site 18

Approximately 1,200 gpd of sewage is discharged to a 1,000 gallon septic tank and sand-filter with post chlorination. The effluent is discharged to the Buffalo River.

Site 9

This installation has no permanent personnel and is used for drill practices by the National Guard. Approximately 2,000 gallons per month is discharged to a 1,000 gallon septic tank and subsurface disposal field.

The waste disposal practices at the above NIKE installations appear adequate.

Post Office, Springville, New York

Sewage, 160 gpd, from 10 to 12 employees is discharged to a septic tank system. The City of Springville has recently constructed a sanitary sewerage system to which the Post Office could make a connection.

Iroquois National Wildlife Refuge, Genesee County, New York

This facility is served by four separate septic tank systems with subsurface disposal fields. The installation has a Job Corps Center under construction which will be served by a septic tank and disposal field system. It is anticipated that this center will have a population of 130. The waste disposal systems appear to be operating satisfactorily.

Niagara Municipal Airport Air Base Group, New York

Sewage and airplane wastes are treated by a sewage treatment plant consisting of two Imhoff tanks and six intermittent sand-filters. Although chlorination facilities are available, they are not being used. Approximately 80,000 gpd is discharged to the Cayuga Creek.

Coast Guard Installations, Lake Erie

Toledo Harbor Light Station, Ohio

This station, located in the outer Toledo Harbor, discharges raw sewage from a complement of two. The Coast Guard is in the process of installing automatic equipment at the light station, and the station will not be a manned facility after October 1, 1965.

Marblehead Lifeboat Station, Ohio

This facility has a complement of 15 and is served by two septic tanks and a subsurface disposal field. This system is operating satisfactorily. One house trailer at the installation is served by a cesspool consisting of a 50 gallon punched oil drum.

Put-In-Bay Light Station, Ohio

This facility consists of a houseboat which is unmanned at this time. The houseboat is served by a retention tank with chlorination.

Sandusky Bay Lifeboat Station, Ohio

This installation has a complement of 25 and is served by three septic tanks and a subsurface disposal field. The sewerage system appears to be operating well.

Lorain Lifeboat Station, Ohio

This installation has a complement of 12 and is served by a septic tank which discharges directly to the Black River. This facility is located less than 400 yards from the Lorain Sewage Treatment Plant. The outer harbor light station has a complement of two to three persons and discharges raw sewage into Lake Erie.

Cleveland Lifeboat Station, Ohio

This installation has a complement of 27 and is served by a septic tank which discharges directly to Lake Erie without further treatment. The light station was automated on July 1, 1965, and is no longer a manned facility. The Marine Inspection Office, which is located at the foot of Ninth Street in Cleveland, is served by a septic tank with direct discharge to the harbor.

Fairport Harbor Lifeboat Station, Ohio

This installation has a complement of 10 and is served by a septic tank with direct discharge to the Grand River.

Ashtabula Light Station

This station is located in the outer harbor and is manned by one to two persons. Sewage is discharged directly to Lake Erie without treatment. No definite plans have been made to automate this station.

Chesterland Radio Station, Gates Mills, Ohio

This facility has a complement of 21 and is served by a septic tank and subsurface disposal field. The system seems adequate.

Erie Lifeboat Station, Presque Isle, Pennsylvania

This station has a complement of 23 and is served by a septic tank and subsurface disposal field. The system seems adequate.

Buffalo Lifeboat Station, New York

This installation has a complement of 20 and is served by a small aerobic package plant that provides secondary treatment. The treatment plant appears to be operating satisfactorily.

TABLE V-1
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
OHIO						
Maumee River	6586.3*					
Auglaize River	2448.2*	190,995	7,240	16,600	---	167,155
Lower Maumee River		623,910	5,035	5,815	3,660	609,400
St. Joseph River	1060.4*	11,780	---	3,330	8,450	---
St. Marys River	816.7*	22,560	---	2,600	440	19,520
Tiffin River	804.5*	44,915	2,395	2,045	---	40,475
Upper Maumee River		13,735	1,465	1,020	9,650	1,600
Totals for Maumee River		907,895	16,135	31,410	22,200	838,150

1 Unsewered, presently under state order to provide waste collection and treatment facilities
2 Remaining unsewered population

* Drainage area for Maumee River includes 4,856.2 sq. miles in Ohio, 1,260.0 sq. miles in Indiana, 470.1 sq. miles in Michigan
Drainage area for Auglaize River includes 2,341.6 sq. miles in Ohio, 106.6 sq. miles in Indiana
Drainage area for St. Joseph River includes 238.0 sq. miles in Ohio, 603.2 sq. miles in Indiana, 219.2 sq. miles in Michigan
Drainage area for St. Marys River includes 457.7 sq. miles in Ohio, 359.0 sq. miles in Indiana
Drainage area for Tiffin River includes 553.5 sq. miles in Ohio, 251.0 sq. miles in Michigan

TABLE V-1 "Continued"
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Ward Canal		450	---	450	---	---
Halfway Creek	18.81	5,000	---	5,000	---	---
Ottawa River	178.51	10,525	---	1,325	---	9,200
Cedar Creek	49.91	3,150	---	950	2,200	---
Crane Creek	54.04	1,565	---	1,565	---	---
Turtle Creek	28.66	665	---	665	---	---
Toussaint Creek	142.29	4,610	---	2,325	---	2,285
Portage River	587.2	75,270	4,905	9,715	4,075	56,575
Muddy Creek	105.59	1,210	---	630	---	580
Raccoon Creek	30.09	2,500	---	---	---	2,500
Strong Creek	30.56	830	---	285	---	545
Sandusky River	1420.7	102,240	1,800	11,830	22,080	66,530
Mills Creek	36.44	160	---	160	---	---
Pipe Creek	26.73	1,500	---	---	---	1,500
Cold Creek	8.17	955	---	955	---	---
Old Woman Creek	30.37	970	---	970	---	---
Huron River	403.4	35,870	1,820	1,495	2,205	30,350
Vermilion River	271.7	7,875	730	2,435	---	4,710
Quarry River		2,480	---	---	---	2,480
Quarry Creek	6.51	4,505	---	1,655	---	2,850
Martin Run	4.26	3,000	---	3,000	---	---
Black River	466.8	65,600	1,005	7,570	---	57,025
Cahoon Creek	5.44	12,905	12,905	---	---	---
Rocky River	293.8	67,847	1,904	10,393	430	55,120
Cuyahoga River	813.3	1,177,138	14,798	20,155	19,765	1,122,420
Euclid Creek	23.15	1,200	---	---	---	1,200
Chagrin River	267.0	24,480	---	12,325	7,950	4,205
Mentor Marsh		3,640	---	---	3,640	---

TABLE V-1 "Continued"
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Arcola Creek	10.15	1,970	---	500	---	1,470
Grand River	712.1	31,225	---	6,840	19,460	4,925
Wheeler Creek		500	---	500	---	---
Cowles Creek	22.18	5,380	---	---	---	5,380
Indian Creek	16.84	350	---	350	---	---
Ashtabula River	137.1	1,095	---	1,095	---	---
Conneaut River	191.2***	5,130	---	5,130	---	---
Direct to Lake Erie		1,770,085	1,635	7,455	652,900	1,108,095
		4,599,975	59,682	169,538	756,905	3,613,850
INDIANA						
Maumee River	6586.3*					
St. Joseph River	1060.4*	20,020	---	5,105	---	14,915
St. Marys River	816.7*	16,940	---	10,050	---	6,890
Upper Maumee River		212,925	---	985	---	211,940
		249,885	---	16,140	---	233,745
MICHIGAN						
St. Clair River-Lake St. Clair Basin						
Black River	690	20,800	---	4,100	---	16,700
Belle River	210	9,000	---	600	---	8,400
St. Clair River		63,100	---	3,200	59,900	---
Clinton River	760	288,500	---	66,500	---	222,000
Lake St. Clair		9,000	---	2,500	---	6,500
Totals for basin		390,400**	---	76,900	59,900	253,600

** Population does not include communities discharging to interceptor systems connected to Detroit Sewage Treatment Plant.

***Drainage area for Conneaut River includes 37.7 sq. miles in Ohio and 153.5 sq. miles in Pennsylvania

TABLE V-1 "Continued"
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Detroit River		3,457,400	---	135,800	3,321,600	---
Huron River	892	171,600	---	17,000	8,900	145,700
Raisin River	1070	60,000	---	7,000	25,600	27,400
Maumee River Basin	6586.3*					
St. Joseph River	1060.4*	2,700	---	2,700	---	---
Tiffin River	804.5*	6,645	2,055	2,040	---	2,550
Direct to Lake		9,400	---	9,400	---	---
		4,098,145	2,055	250,340	3,416,000	429,250
PENNSYLVANIA						
Conneaut River	191.2***	4,440	---	2,060	---	2,380
Raccoon Creek	8.95	500	---	---	---	500
Crooked Creek	21.2	760	---	760	---	---
Elk Creek	101	5,660	---	915	25	4,720
Trout Run	5.88	1,640	---	---	---	1,640
Walnut Creek	36.1	2,000	---	---	---	2,000
Sevenmile Creek	8.70	255	---	---	---	255
Sixteenmile Creek	18.4	13,145	---	---	---	13,145
Direct to Lake Erie		173,500	---	500	---	173,000
		201,900	---	4,235	25	197,640
NEW YORK						
Chautaqua Creek	36	3,800	---	---	---	3,800
Cornell Creek		500	---	500	---	---
Slippery Rock Creek		1,415	1,415	---	---	---
Beaver Creek		130	130	---	---	---
Canadaway Creek	40	37,640	140	---	---	37,500
Silver Creek	52	4,215	---	4,215	---	---
Cattaraugus Creek	565	18,035	130	8,150	7,825	1,930

TABLE V-1 "Concluded"
LAKE ERIE MUNICIPAL WASTE TREATMENT FACILITIES

River Subbasin	Drainage Area (sq. miles)	Estimated Population Equivalent				
		Total	Unsewered		Sewered	
			1	2	Primary	Secondary
Big Sister Creek		5,240	---	3,665	---	1,575
Muddy Creek		422	---	422	---	---
Pike Creek		2,500	---	2,500	---	---
Eighteenmile Creek	110	17,155	300	1,400	5,920	9,535
Rush Creek		25,300	---	600	---	24,700
Smoke Creek		42,035	---	5,855	290	35,890
Buffalo River	842					
Buffalo River		22,110	---	590	6,320	15,200
Buffalo Creek		4,785	4,000	785	---	---
Cayuga Creek		17,160	---	300	13,700	3,160
Cazenovia Creek		27,895	---	2,925	---	24,970
Totals for Buffalo River		71,950	4,000	4,600	20,020	43,330
Niagara River U. S. Sub-basin						
Niagara River		1,163,174	---	2,400	1,099,174	61,600
Tonawanda Creek	768	71,055	---	960	4,945	65,150
Totals for basin		1,234,229	---	3,360	1,104,119	126,750
Direct to Lake Erie		31,320	700	8,015	22,605	---
		1,495,886	6,815	43,282	1,160,779	285,010

Table V-2

INDUSTRIES IN LAKE ERIE BASIN DISCHARGING DIRECTLY TO PUBLIC WATERS

River Subbasin	Total Industrial Plants	Industrial Plants With Inadequate Treatment[1]
Ohio		
Maumee River		
Auglaize River	11	2
Lower Maumee River	9	1
St. Joseph River	2	--
St. Marys River	3	--
Tiffin River	1	--
Upper Maumee River	3	1
Totals for Maumee	29	4
Portage River	7	1
Sandusky River	5	--
Huron River	2	1
Black River	13	1
Rocky River	2	--
Cuyahoga River	24	16
Chagrin River	5	--
Grand River	5	1
Ashtabula River	6	3
Minor Tributaries to Lake	10	2
Direct to Lake	10	1
Total for Ohio	118	30
Indiana		
Maumee River		
St. Joseph River	4	--
St. Marys River	2	1
Upper Maumee River	7	1
Total	13	2

[1] Status of waste treatment facilities as reported by state water pollution control agencies.

Table V-2 (continued)

INDUSTRIES IN LAKE ERIE BASIN DISCHARGING DIRECTLY TO PUBLIC WATERS

River Subbasin	Total Industrial Plants	Industrial Plants With Inadequate Treatment[1]
Michigan		
Detroit River	21	5
Rouge River	14	5
Total for Basin	35	10
Huron River	12	1
Raisin River	9	6
Direct to Lake	1	--
Total for Michigan	57	17

[1] Status of waste treatment facilities as reported by state water pollution control agencies.

Table V-2 (concluded)

INDUSTRIES IN LAKE ERIE BASIN DISCHARGING DIRECTLY TO PUBLIC WATERS

River Subbasin	Total Industrial Plants With Adequate Treatment	Industries With Inadequate Treatment[1]
Pennsylvania		
Conneaut River	1	--
Tributaries to Lake	5	--
Direct to Lake	1	2
Total for Pennsylvania	7	2
New York		
Buffalo River	2	4
Cattaraugus Creek	2	--
Tributaries to Lake	6	--
Total for New York	10	4

[1] Status of Waste Treatment Facilities as reported by State water pollution control agencies.

Table V - 3

LAKE ERIE

INDUSTRIAL WASTES DISCHARGED DIRECTLY TO LAKE-AFFECTED PORTIONS OF RIVERS

Industry	Type of Waste	State Classification Required Improvements Reported by State Agency	
Ohio			
	Maumee River (0 - 14.9 Miles)		
Standard Oil Co.	Oil Refinery		
Gulf Oil Co.	Oil Refinery		
Interlake Iron	Steel		Solids
Sun Oil Co.	Oil Refinery		
Toledo Edison	Power		
Libbey-Owens Fords	Glass Manufacture		
Allied Chemical	Plastics		
	Black River (0 - 10.2 Miles)		
U. S. Steel Corp.	Steel		
	Cuyahoga River (0 - 6.6 Miles)		
Republic Steel	Steel		
Bolt & Nut Div.	Acid Iron	I	Pickling Liquor
Mill Scale			
Standard Oil Corp.	Oil Refinery		
#1		I	Oil and phenol
#2			
U. S. Steel Corp.	Steel		
Blast Furnace		I	Solids
Pickling		I	Pickling Liquor
Mill Scale		I	Solids
E. I. DuPont	Chemical	I	Metals
Republic Steel			
Coke Plant			
Blast Furnace		I	Solids - Increase efficiency
Rolling Mill		I	Oil & Solids - Increase efficiency
Pickling			

I - inadequate as reported by State water pollution control agencies.

Table V - 3 (Continued)

LAKE ERIE

INDUSTRIAL WASTES DISCHARGED DIRECTLY TO LAKE-AFFECTED PORTIONS OF RIVERS

Industry	Type of Waste	State Classification Required Improvements Reported by State agency	
Cuyahoga River (0 - 6.6 Miles)			
J. L. Steel Corp.	Steel	I	Pickling Liquor
Pickling		I	Pickling Liquor
Blast Furnace			
Mill Scale			
Harshaw Chemical Co.	Chemicals	I	Reduction of metallic salts
Sherwin-Williams	Chemicals	I	Acids & Alkaline Sludges
Elco Lubricant Corp.	Oil	I	Acids & Alkaline Sludges
Grand River (0 - 2.3 Miles)			
Diamond Alkali Co.	Chemical		
U. S. Rubber Co.	Chemical		
Ashtabula River (0 - 3.3 Miles)			
Olin Mathieson	Chemical	I	Solids pH
Cabot Titania Corp.	Chemical	I	Solids
Titania Dioxide Plant	Chemical	I	Solids
Titania Tetrachloride	Chemical	I	Solids - Chloride
Detrex Chemical Ind.	Chemical	I	Iron Hydrocarbon
Reactive Metals	Chemical		
Sodium & Chloride			
Plant		I	Solids
Metal Reduction			
Plant		I	Solids and pH
Extrusion Plant			
Diamond Alkali Co.	Chemical	I	Solids
General Tire & Rubber Co.	Chemical	I	Solids

I - inadequate as reported by State water pollution control agencies.

Table V - 3 (Continued)

LAKE ERIE

INDUSTRIAL WASTES DISCHARGED DIRECTLY TO LAKE-AFFECTED PORTIONS OF RIVERS

Industry	Type of Waste	State Classification Required Improvements Reported by State Agency	
	Direct to Lake Erie		
Aluminum & Magnesium Co., Sandusky, Ohio	Metals		
United States Gypsum Gypsum	Paper	I	Solids
Cleveland Electric Illuminating Co.	Power		
Avon Lake		I	Solids
Eastlake			
Ashtabula			
Ohio Edison Co.	Power		
Lorain			
The Lubrizol Corp.	Chemical		
Wickliffe			
Thompson Ramo Woolridge			
Euclid	Metal Finishing	I	Metals Reduction
Industrial Rayon Co.	Textile	I	Metals Reduction
Painesville			
Union Carbide Corp.	Steel Acid-Iron		
Metals Division			
Ashtabula			
Detrex Chemical Ind.	Chemical		
Chloro-Alkali			
Plant			
Ashtabula			
Pennsylvania			
	Direct to Lake Erie		
Hammermill Paper Co. Erie, Pa.	Paper	I	
Interlake Iron Corp. Erie, Pa.	Metal	I	
Pennsylvania Electric Erie, Pa.	Flyash		

I - inadequate as reported by State water pollution control agencies.

Table V - 3 (Continued)

LAKE ERIE

INDUSTRIAL WASTES DISCHARGED DIRECTLY TO LAKE-AFFECTED PORTIONS OF RIVERS

Industry	Type of Waste	State Classification Required Improvements Reported by State Agency
New York		
	Direct to Lake Erie	
Bethlehem Steel Co. Lackawanna	Steel	
Penn-Dixie Cement Co.	Inorganic Solids	I
Michigan		
	Direct to Lake Erie	
Detroit Edison Enrico-Fermi Station	Power	

I - inadequate as reported by State water pollution control agencies.

TABLE V-4
CHLORIDE INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Head of Detroit River	6,500,000
Additions to Detroit River (incl.Canada)	11,500,000
Discharges by	
Huron River	90,000
Raisin River	140,000
OHIO	
Discharges by	
Maumee River	440,000
Portage River	100,000
Sandusky River	170,000
Black River	170,000
Rocky River	110,000
Cuyahoga River	660,000
Chagrin River	60,000
Grand River	2,200,000
Ashtabula River	20,000
Municipalities	
Toledo	80,000
Sandusky	7,000
Lorain-Avon	17,000
Lakewood	10,000
Cleveland-Westerly	37,000
Cleveland-Easterly	140,000
Euclid	14,000
Industrial--Direct to Lake--Ohio	unknown
PENNSYLVANIA	
Municipalities	
Erie	12,000
Small Sources	-
Industrial	unknown
NEW YORK	
Buffalo River	70,000
Other Sources	4,000
CANADA (other than Detroit River)	unknown
Sum of Known Sources	22,551,000
Discharged at Niagara River	25,100,000

TABLE V-6
SUSPENDED SOLIDS INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Discharge by	
Detroit River	8,600,000
Huron River	10,000
Raisin River	48,000
OHIO	
Maumee River	1,600,000
Portage River	130,000
Sandusky River	130,000
Black River	73,000
Rocky River	84,000
Cuyahoga River	490,000
Chagrin River	70,000
Grand River	360,000
Ashtabula River	15,000
NEW YORK	
Buffalo River	100,000
TOTALS--Major Known Sources	11,710,000

TABLE V-7
TOTAL NITROGEN INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Discharge by	
Detroit River	500,000
Huron River	1,600
Raisin River	3,800
OHIO	
Tributaries	
Maumee River	65,000
Portage River	19,600
Sandusky River	*
Black River	13,200
Rocky River	*
Cuyahoga River	52,100
Chagrin River	*
Grand River	4,000
Ashtabula River	*
Municipalities	
Toledo	40,000
Sandusky	3,500
Lorain-Avon	8,700
Lakewood	5,200
Cleveland-Westerly	19,000
Cleveland-Easterly	71,000
Euclid	6,900
Industrial--Direct to Lake	*
PENNSYLVANIA	
Erie	12,000
NEW YORK	
Buffalo River	*
Other Sources	2,100
CANADA (other than Detroit River)	*
Sum of Known Inputs	821,700

* unknown

TABLE V-8
SOLUBLE PHOSPHATE INPUTS TO LAKE ERIE

Source	Pounds/Day
MICHIGAN	
Discharge from Lake Huron	11,800
Municipal	70,000
Industrial	10,000
Tributaries	
Huron River	2,000
Raisin River	900
OHIO	
Municipalities	
Toledo	8,400
Sandusky	1,000
Lorain-Avon	2,600
Lakewood	1,100
Cleveland Westerly	5,400
Cleveland Easterly	14,900
Euclid	2,100
Industrial--Direct Discharge	unknown
Tributaries	
Maumee River	11,000
Portage River	1,100
Sandusky River	6,000
Black River	3,100
Rocky River	3,400
Cuyahoga River	3,500
Chagrin River	300
Grand River	--
Ashtabula River	100
PENNSYLVANIA	
Erie	2,600
Other Sources	2,900
NEW YORK	
Buffalo River	2,300
Other Sources	2,500
CANADA (est.-Municipal)	5,000
Sum of Major Known Sources	174,000
Discharged at Niagara River	24,000

* U. S. GOVERNMENT PRINTING OFFICE : 1969 O - 783-553